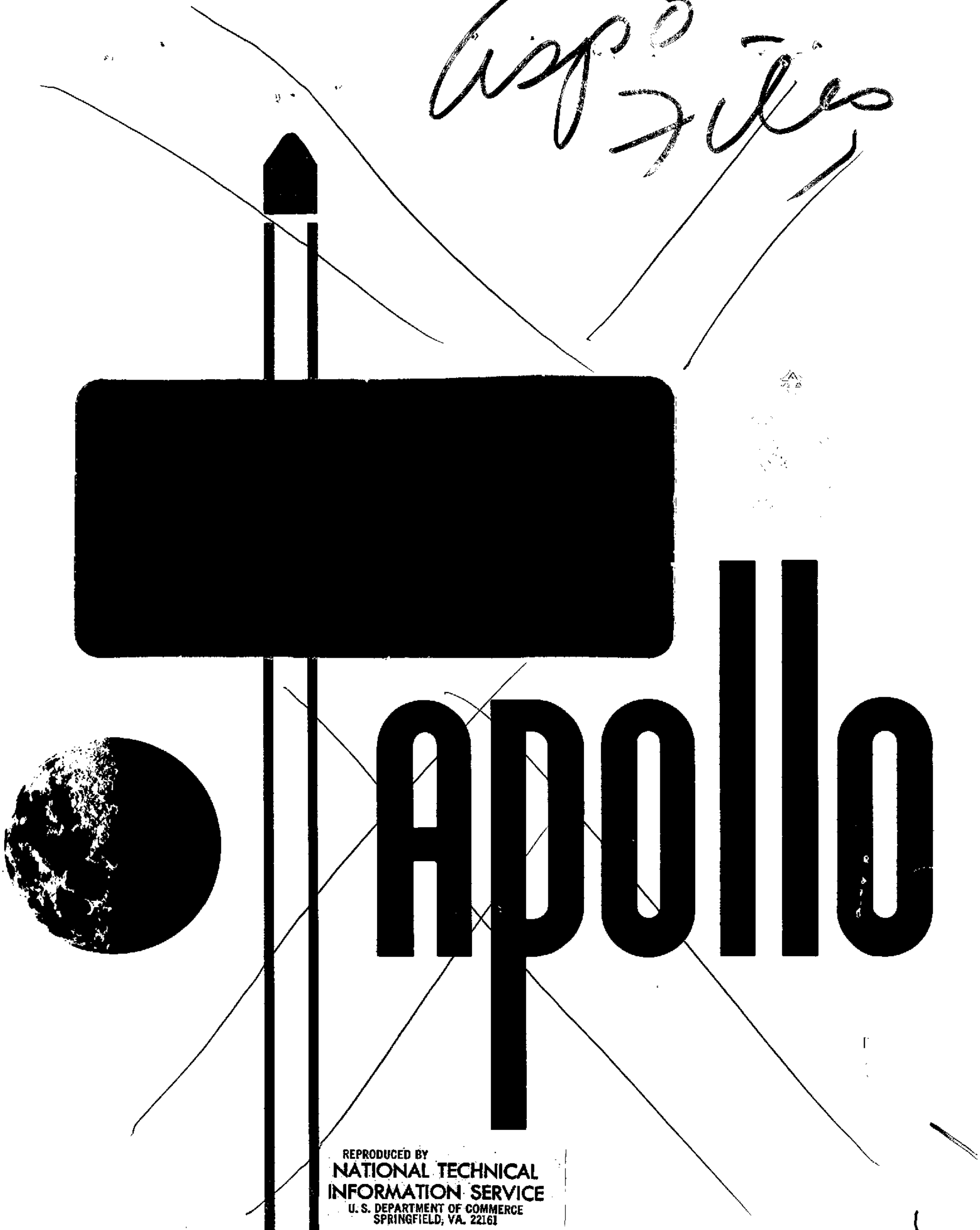




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# AUTOMATED CONTROL SUBSYSTEM DEVELOPMENT PLAN

NAS9-150

1 April 1965



NORTH AMERICAN AVIATION, INC.
SPACE and INFORMATION SYSTEMS DIVISION

NORTH AMERICAN AVIATION, INC. SPACE and INFORMATION SYSTEMS DIVISION

# TECHNICAL REPORT INDEX/ABSTRACT

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DESCRIPTIVE TERMS The subsystem development plan has been prepared in accordance with the documentation requirements of the Apollo, Program Plan, SID 62-223. The SDP has also been prepared in accordance with the qualification ground rules contained in the Technical Specifications SID 63-313 and SID 64-1344. The SDP supports the flight and ground programs specified in The Development Test Plan, SID 64-1707.

ABSTRACT

This subsystem development plan (SDP) defines the analysis and testing leading to the use of automated subsystems on Apollo unmanned missions. At the subsystem level it provides direction and guidance for detailed planning, provisioning, and other development activities performed by S&ID and its subcontractors. These activities include the development and qualification programs for the hardware evolution from the component-module level to qualified subsystems. They also include the analysis, simulation, and laboratory testing required for mating the automated subsystem to the spacecraft.

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# 1.0 INTRODUCTION

## 1.1 PURPOSE AND SCOPE

This subsystem development plan (SDP) defines the analysis and testing leading to the use of automated subsystems on Apollo unmanned missions. At the subsystem level it provides direction and guidance for detailed planning, provisioning, and other development activities performed by S&ID and its subcontractors. These activities include the development and qualification programs for the hardware evolution from the component-module level to qualified subsystems. They also include the analysis, simulation, and laboratory testing required for mating the automated subsystem to the spacecraft. Figure 1-1 illustrates these development activities.

## 1.2 RELATIONSHIP TO OTHER DOCUMENTS

The subsystem development plan has been prepared in accordance with the documentation requirements of the Apollo Program Plan, SID 62-223, and with the qualification ground rules contained in the technical specifications SID 63-313 and SID 64-1344, unless otherwise noted in the text. The SDP supports flight and ground programs specified in MDS-8, Revision 2, and the Development Test Plan, SID 64-1707.

The schedules contained herein are compatible with contractual commitments as of the effectivity dates shown on each schedule. In event of conflict with the Apollo Schedule Manual, the ASM has precedence.

## 1.3 REVISION

To ensure that the SDP maintains its value as a directive document, it will be revised as required, rather than periodically. Revisions required by technical redirection will be incorporated upon receipt of a contract's advice notice stating NAA's position. S&ID-proposed revisions to the SDP are to be submitted to Automated Systems, Department 697-540.

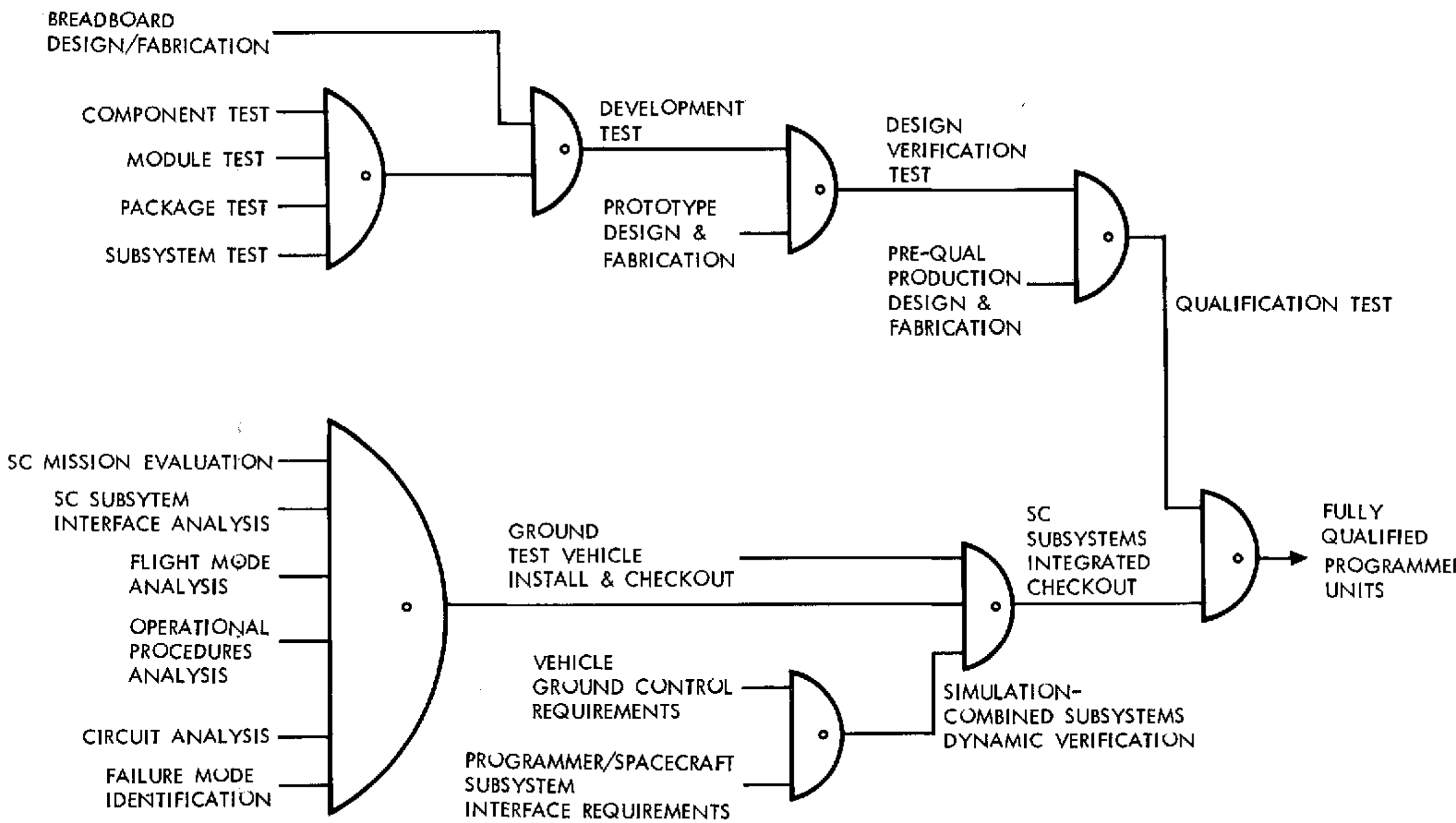


Figure 1-1. Automated Subsystem Development Logic

## 2.0 DEVELOPMENT PROGRAM SUMMARY

The existence of requirements for two types of programmers has necessitated development and fabrication programs to support both the Spacecraft 009 control programmer and the Block I mission control programmer. Past and future milestones are listed in Table 2-1.

Table 2-1. Milestones

| Milestones | Milestone Date |
|---|---|
| Past | |
| CCA 155, control programmer | March 1964 |
| Major IDWA, control programmer | June 1964 |
| Purchase order, attitude reference | July 1964 |
| CCA 164, Revision 1, mission control programmer | July 1964 |
| MCP singular design concept | October 1964 |
| Breadboard CP, SCS, and RCE interface testing completed | January 1965 |
| SC 009 attitude reference system delivered | February 1965 |
| Future | |
| Block II programmer design definition | June 1965 |
| Delivery first production control programmer | May 1965 |
| Delivery first production MCP | August 1965 |
| Start CP qualification test | June 1965 |
| Start MCP qualification test | August 1965 |

## 2.1 SPACECRAFT 009 CONTROL PROGRAMMER

The control programmer effort consists of the development and fabrication of one engineering breadboard and two engineering model prototypes. The breadboard will be utilized for early development testing and will later be shipped to S&ID for laboratory evaluation. One prototype will be delivered to S&ID for simulation studies, and the other will be retained by the supplier for prequalification testing. Three production systems are being built, one for Spacecraft 009 and two for qualification testing. Schedule compliance with Spacecraft 009 normal installation dates has required a work-around support plan. The prototype unit scheduled for simulation studies will be initially installed in Spacecraft 009 and replaced upon production unit availability prior to integrated subsystems testing. Three sets of test equipment are being built to support the control programmer production and qualification test programs. One unit of test equipment is scheduled for delivery to S&ID for ultimate use as field test equipment; the other two sets will be used to support the qualification test program.

Three attitude reference subsystems (ARS) are being procured. One ARS is for Spacecraft 009, and the other two are for laboratory evaluation and simulation studies.

## 2.2 BLOCK I MISSION CONTROL PROGRAMMER

The Block I mission control programmer effort consists of developing and fabricating one breadboard, two prototypes, and seven production units. Two of the production units are identified as contingency units. The contingency units support the possibility of Spacecraft 012 or 014 being reconfigured to unmanned vehicles should the flight test logic dictate. A similar schedule approach exists for Spacecraft 011 as for Spacecraft 009, in that interim support is required to preserve installation need date compliance. Production unit replacement occurs during the downstream modification period at Downey prior to integrated subsystems tests.

# 3.0 SUBSYSTEM MISSION OBJECTIVES

## 3.1 AUTOMATED SUBSYSTEM CONCEPTS

The need for programming devices is clearly identified by the unmanned phases of the test logic inherent in flight verification of those spacecraft subsystems unique to the full lunar orbital rendezvous (LOR) qualification objective. Unmanned flights are required to prove that the vehicle is safe enough to commit it to manned operation. The automated subsystem is that equipment added to the basic Apollo spacecraft so that unmanned development flights can be performed.

### 3.1.1 Spacecraft 009 Concept

Spacecraft subsystem complement differences between Spacecraft 009 and the remaining Block I unmanned spacecraft have required the development of two programmer concepts. The deletion of a guidance and navigation subsystem from the Spacecraft 009 configuration requires that an active element be provided for time base and vehicle maneuvering requirements. This element is referred to as the control programmer (CP). Also required is an inertial reference instrument to relay backup spacecraft attitude information to ground control. This element is referred to as the attitude reference subsystem (ARS). The CP and ARS represent two of the seven control elements which provide the total required automation of Spacecraft 009. This complement of control elements is commonly referred to as the "mechanical boy" concept. This development plan is concerned with only the CP and ARS.

### 3.1.2 Spacecraft 011 and Subsystem Concept

The programmer concept for the remaining Block I unmanned spacecraft utilizes a programming device in series with discrete keying commands from the guidance and navigation subsystem and the S-IVB instrumentation unit. The commands from these subsystems initiate logic sequences within the programmer for control of mission essential functions. This programming device is referred to as the mission control programmer (MCP). The MCP represents the automated subsystem for the Block I unmanned spacecraft, excluding Spacecraft 009. The MCP has commonly been referred to as the "mechanical man" concept. In contrast to the control programmer, which is one of several "mechanical boy" components, the MCP performs all functions unique to unmanned spacecraft.

A kit concept has been developed for the MCP. The automation kit approach facilitates rapid installation of the MCP into manned spacecraft should the flight qualification test logic dictate. Spacecraft 011, 017, and 020 are defined as unmanned vehicles, and the MCP is permanently installed in these vehicles.

### 3.1.3 Block II Concept

Because specific unmanned mission requirements for Block II vehicles have not been established, no firm commitments can be made with regard to a programmer configuration. However, initial investigation indicates that the Block I MCP design can be extended to accommodate Block II requirements. The probable minimum modification will not be in concept but rather in the point-to-point wiring required to interface the MCP with advance versions of other spacecraft subsystems.

## 3.2 AUTOMATED SUBSYSTEM OBJECTIVES

### 3.2.1 Control Programmer

The performance and operational objectives of the control programmer are described in engineering component specification, SID 64-693. The purpose of the programmer, in general, is to provide an automated subsystem that will execute the timed sequential switching required to perform Mission 201. To achieve this mission, the following mandatory capability objectives have been established.

1. Provide the capability to perform predetermined attitude maneuvers
2. Provide the capability to trim and fire the SPS engine
3. Provide the capability to overcome certain critical subsystem failures
4. Provide the capability to perform an SPS abort independent of ground control
5. Provide the capability to monitor vehicle inertial attitude information for ground control purposes
6. Provide the capability to sense 0.05 g and provide redundant switching

7. Provide the capability to operate during, and/or after, exposure to the mission environments specified in the applicable CSM end item specification during the following mission phases:

    Ground checkout
    Lift-off and boost
    Coast maneuver
    SCS delta v maneuver
    Entry
    Impact and recovery

### 3.2.2 Mission Control Programmer

The performance and operational objectives of the mission control programmer are described in engineering component specification SID 64-2243. The purpose of the programmer, in general, is to provide an automated subsystem that will perform, upon initiation, the switching functions required to automate G&N-controlled missions 201, 202, 501, and 502.

Accomplishment of these missions requires compliance with the following design objectives.

1. Provide the capability to trim the SPS engine
2. Provide the capability to command a rolling entry
3. Provide the capability to detect and correct certain critical subsystem failures
4. Provide the capability to perform a G&N-controlled SPS abort
5. Provide the capability to sense 0.05 g and impact deceleration, and command module attitude following impact (apex up or down)
6. Provide the capability to operate during, and/or after, exposure to the mission environments specified in the applicable CSM end item specification during the following mission phases:

    Ground checkout
    Lift-off and boost
    Earth orbit
    Injection into elliptical orbit
    Coast
    Entry
    Impact and recovery

# 4.0 AUTOMATED SUBSYSTEM DESCRIPTION

## 4.1 SPACECRAFT 009 AUTOMATED CONTROL SUBSYSTEM DESCRIPTION

The installation of the Spacecraft 009 automated control subsystem in the command module is illustrated in Figure 4-1. A functional block diagram is presented in Figure 4-2. The automated control subsystem for Spacecraft 009 consists of two major subsystems: (1) control programmer and (2) attitude reference subsystem.

### 4.1.1 Control Programmer

The control programmer consists of four units: (1) sequential timer assembly, (2) automatic command controller (ACC), (3) radio command controller (RCC), and (4) deceleration sensor.

Sequential Timer Assembly

There are two main timers in the control programmer, the normal mission timer and the abort timer. The normal mission timer is turned on at S-IVB spacecraft separation and supplies a timed sequence of signals to the ACC, which implements the desired events. The abort timer is started by a signal from the ground and is used only after LES jettison and prior to S-IVB separation. The abort timer supplies a timed sequence of signals to the ACC for spacecraft control during SPS abort.

Automatic Command Controller

The ACC consists of the logic, relays, and relay drivers necessary to accept signals from either of the timers and provide the proper driving functions to the spacecraft subsystems. The ACC also contains the X(t) timer, which computes the time delay required in the SPS abort sequence. The X(t) timer is started at LET jettison and computes a time delay equal to t/128 (t is the time between LET jettison and SPS abort initiation).

Radio Command Controller

The RCC consists of the logic, relays, and relay drivers necessary to accept the commands initiated by the ground control console (in the form of binary signals) and provides the proper driving functions for the spacecraft subsystems to execute the commands. The RCC receives binary

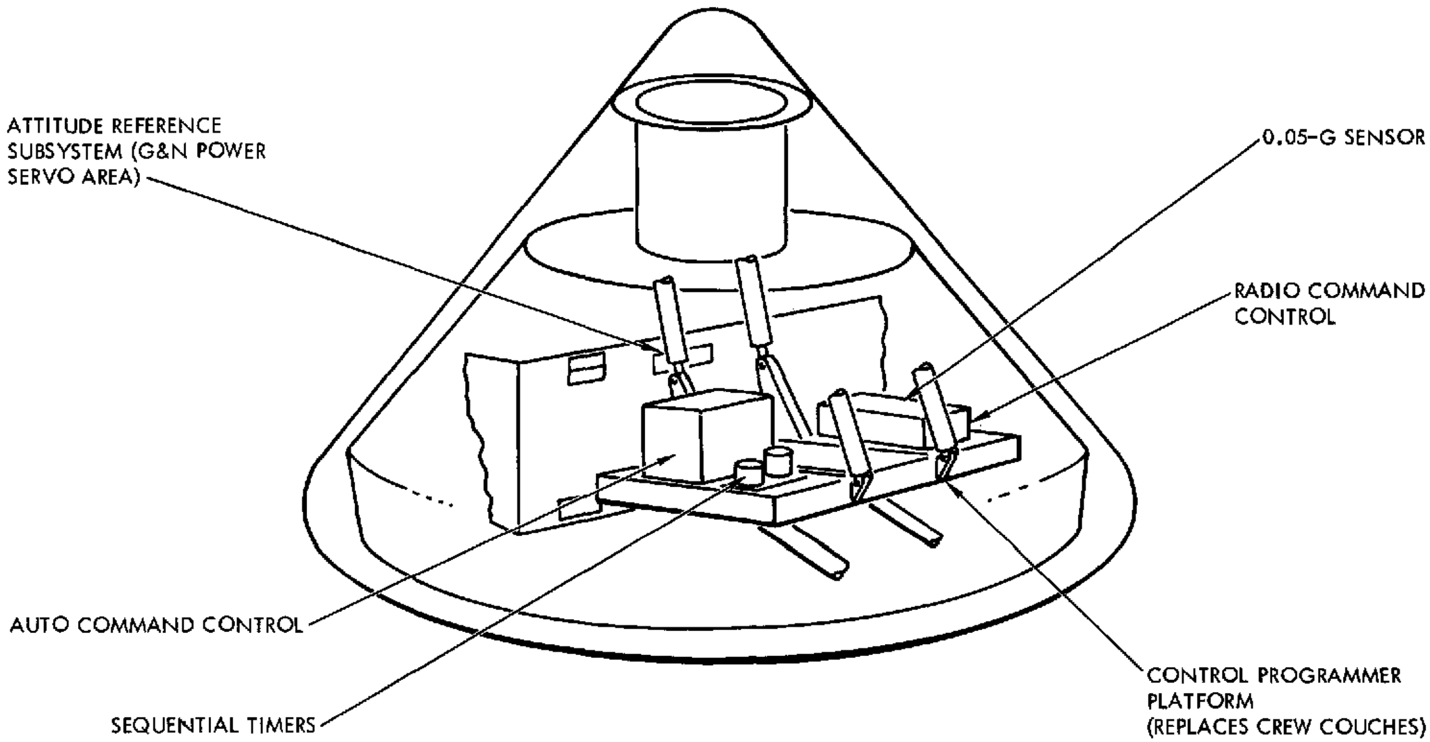


Figure 4-1. Spacecraft 009 Automated Control Subsystem Command Module Installation

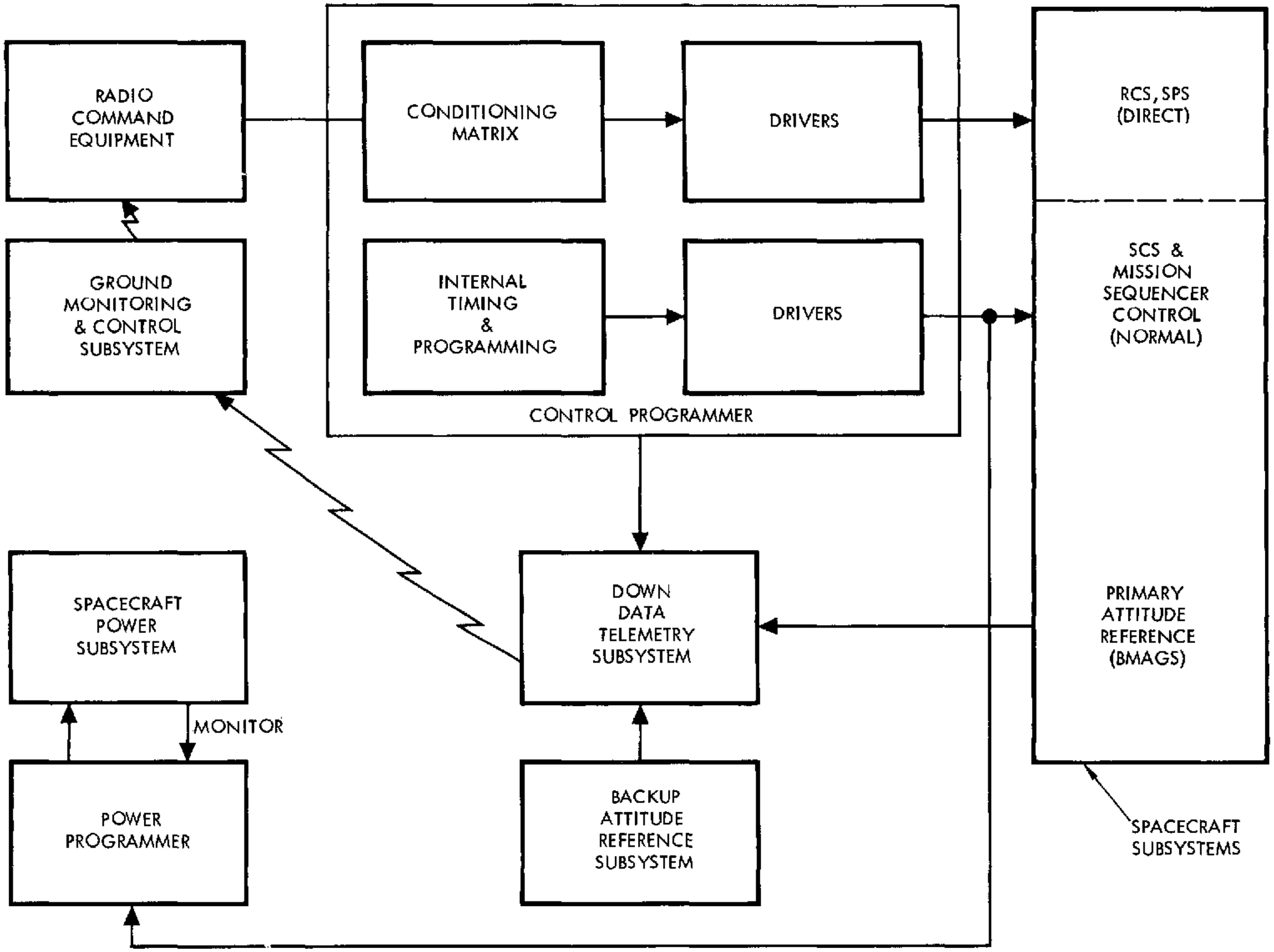


Figure 4-2. Spacecraft 009 Automated Control Subsystem Functional Block Diagram

signals from telemetry, logically determines which command is being requested, and interfaces with the proper spacecraft subsystems to carry out the command.

Deceleration Sensor

The deceleration sensor utilizes two acceleration-sensitive switches, mounted on the right-hand crew couch platform, to provide automatic backup of the SCS 0.05-g sensing. Upon 0.05-g switching, the SCS provides pitch and yaw channel rate stabilization and roll channel attitude hold for the reentry phase of the mission.

### 4.1.2 Attitude Reference

The attitude reference is an instrumentation package comprised of two 2-degree-of-freedom gyros with cageable gimbals and associated electronics for torquing, caging, and signal-conditioning. The attitude reference provides a secondary source of inertial attitude information to ground control via the down-data telemetry system. The attitude reference is designed to withstand all natural and induced environments, although its function is significant only from CSM—S-IVB separation to communications blackout during entry.

## 4.2 MISSION CONTROL PROGRAMMER DESCRIPTION

The mission control programmer consists of three units: (1) ground command controller (GCC), (2) spacecraft command controller (SCC), and (3) attitude and deceleration sensor (ADS). A functional block diagram is presented in Figure 4-3.

### 4.2.1 Ground Command Controller

The GCC consists of the logic, relays, and relay drivers necessary to accept the 64 set-reset pulse commands that are initiated by the ground control console and transmitted via the spacecraft updata link and to provide the proper driving functions to permit the spacecraft subsystems to carry out the commands.

### 4.2.2 Spacecraft Command Controller

The SCC consists of the logic, relays, and relay drivers necessary to accept signals from either the launch control, the S-IVB instrument unit, or the guidance and navigation subsystem and to provide the proper driving functions to the spacecraft subsystems. The SCC also contains automatic sensing and correction circuitry for electrical power subsystem inverter failures and environmental control subsystem glycol-pump failures.

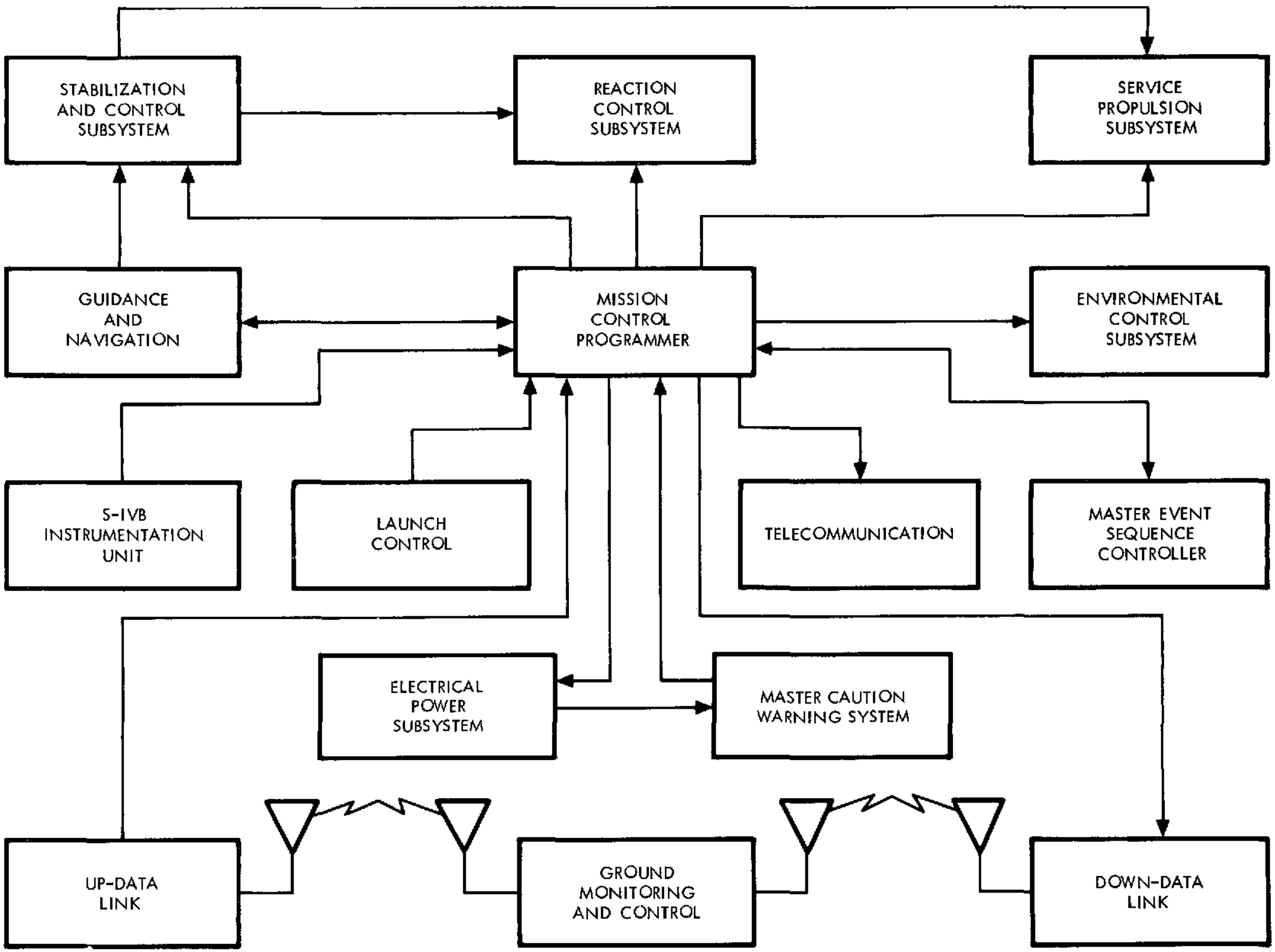


Figure 4-3. Mission Control Programmer Subsystem Block Diagram

### 4.2.3 Attitude and Deceleration Sensor

The ADS includes the sensing devices to perform the following:

1. 0.05-g switching - A deceleration sensor which includes acceleration-sensitive switches provides automatic backup switching of the 0.05-g signal to the stabilization and control subsystem.

2. Impact - An acceleration switch is utilized to provide a signal when command module impact occurs; this signal initiates the deployment of post-landing recovery aids. The efficient utilization of recovery aids requires system knowledge of command module attitude at impact and during the recovery phase. This information is provided by an attitude sensor, which differentiates between command module apex up and down positions.

# 5.0 DEVELOPMENT PLAN

## 5.1 SCOPE

This section delineates the development test plan that has been established to support and provide direction for the development of hardware required for programming of Apollo unmanned missions. This plan encompasses two distinct, but intimately related, areas of test activity. Development plan support is indicated in Figures 5-1 and 5-2.

The first area of development activity consists of the breadboard component, module, package, and subsystem development testing; prototype design verification testing; and environmental qualification of the end-item hardware that composes the automated subsystem. These activities will be performed by the Autonetics Division of NAA. No major development activities are required by the suppliers of some procured items, because they are off-the-shelf qualified items.

The second area of development activity includes S&ID activities involving design verification, testing, and checkout of subsystem-level hardware. The analysis associated with these S&ID activities is considered to be such an integral part of each development phase that it has not been separately identified for discussion in this document.

## 5.2 VENDOR PARTICIPATION

### 5.2.1 Autonetics

The objective of the Autonetics design and development effort is to provide the drawings, specifications, and end-item equipment which reflect the requirements of S&ID procurement specifications MC 901-0480, Control Programmer, dated 12 February 1964, and MC 901-0529, Mission Control Programmer, dated 19 August 1964. Autonetics has the basic responsibility for the selection, design, testing, and delivery of prototype and qualified equipment. S&ID provides contractual performance requirements (by means of specifications), delivery schedule requirements, and general program management.

### 5.2.2 American-Wiancko

The American-Wiancko Company was selected for the attitude reference subsystem for Spacecraft 009. The subsystem being procured

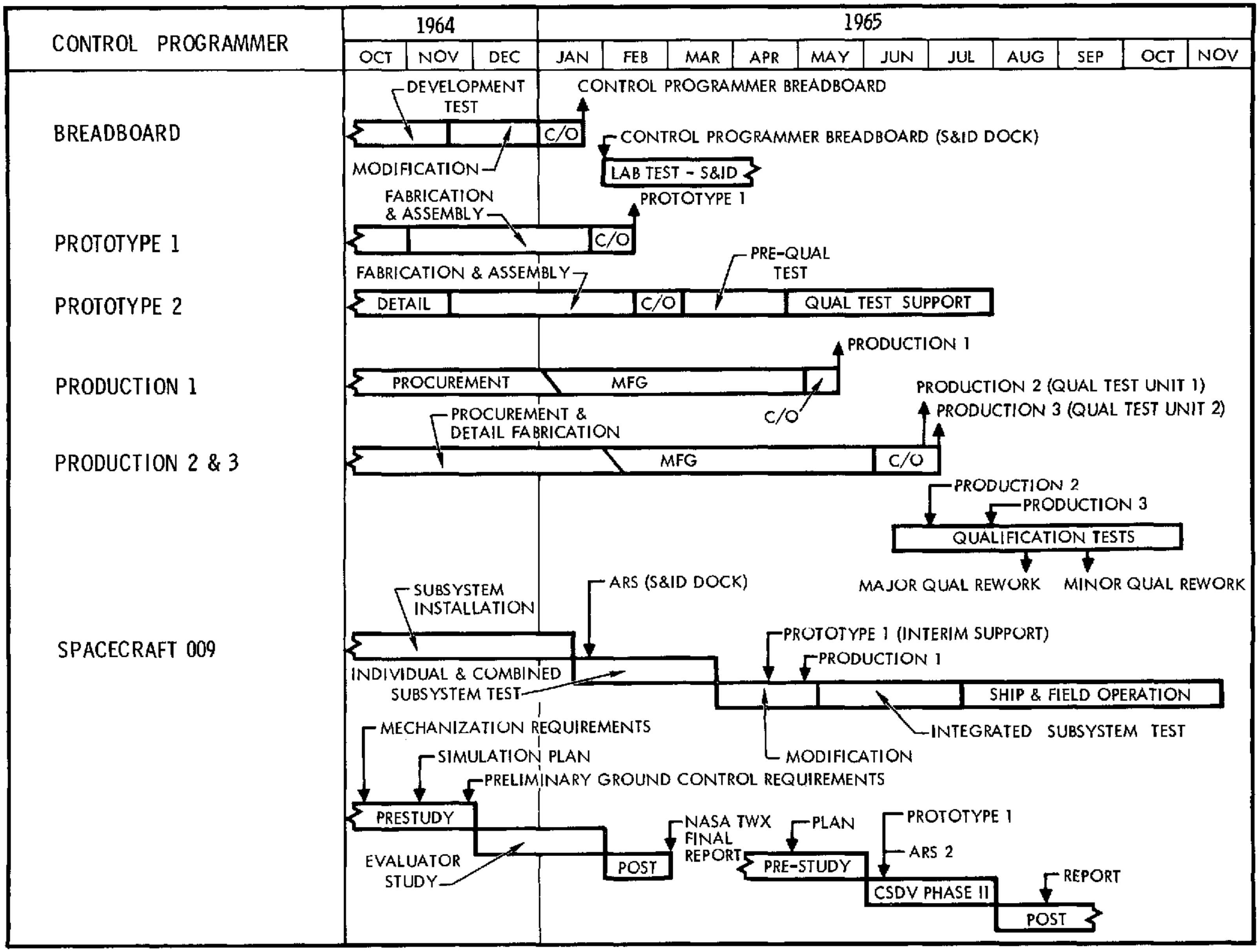


Figure 5-1. Spacecraft 009 Automated Subsystem Development Support

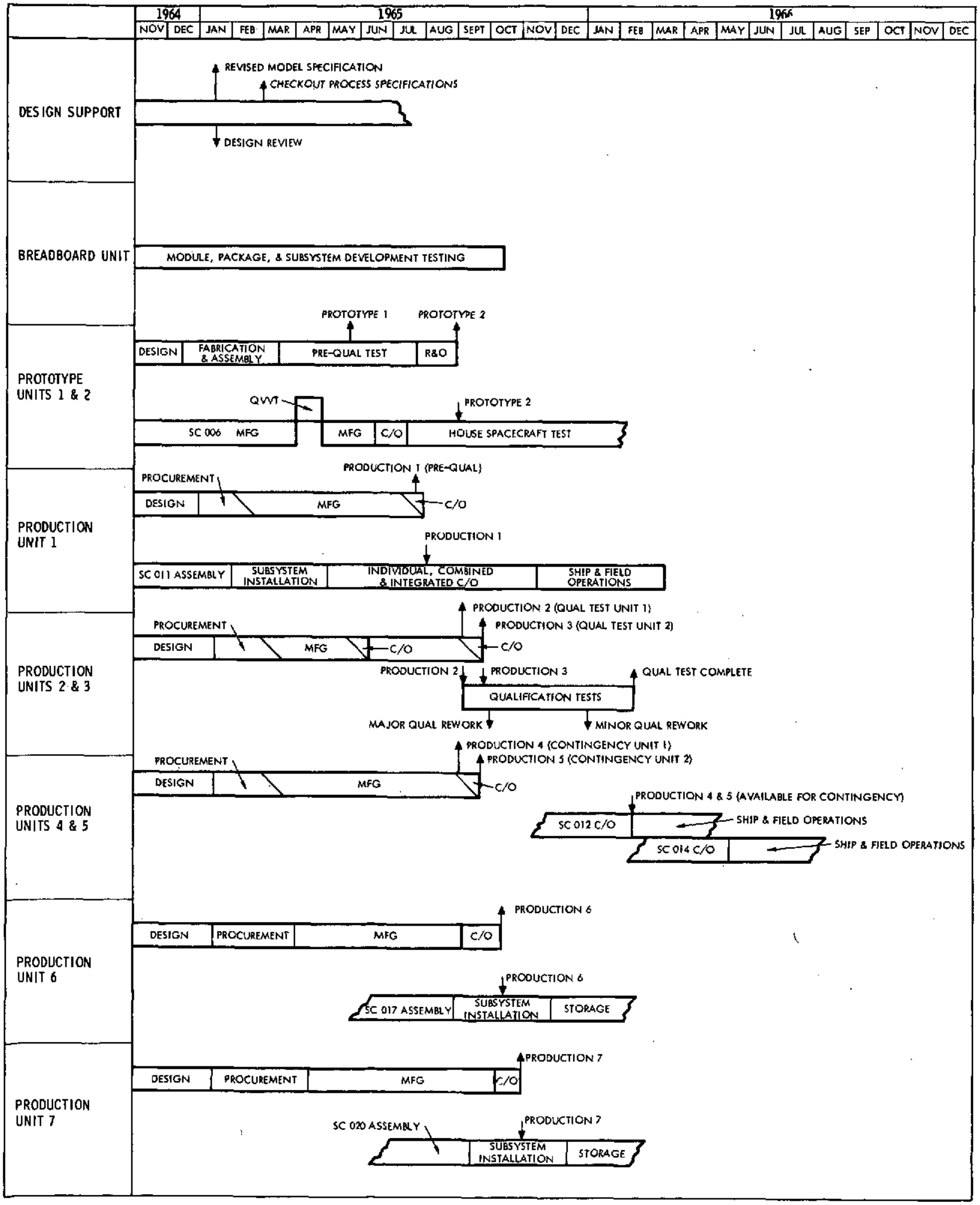


Figure 5-2. Block I Mission Control Programmer Support

contains gyros that were flight-proven during the GAM-77 program. Also, the subsystem represents a minimum modification to an inertial reference subsystem developed by American-Wiancko for (and flight-proven during) the Little Joe II program. The subsystem is being procured and controlled in accordance with S&ID procurement specification MC 901-0477. The subsystem has been qualified by similarity except in those instances precluded by Apollo requirements. Specifically, design proof testing is required for the oxidation, vacuum, humidity, and shock environments.

#### 5.2.3 Humphrey, Inc.

Humphrey, Inc., was selected to supply the 0.05-g backup accelerometer switch for Spacecraft 009. The switch assembly was qualified for the Douglas Super Genie missile program, and a similar unit is being qualified for utilization in the Apollo earth landing subsystem. The unit is being procured and controlled by Engineering Order Purchase Request (EOPR) M283208.

### 5.3 AUTONETICS DEVELOPMENT PLAN

The following paragraphs summarize the Autonetics development and qualification test plans which have been established in order to meet S&ID requirements and schedules.

#### 5.3.1 Autonetics Programmer Development Test Plan

The following is a summary of the type and level of testing to be conducted by the Autonetics Division during the development test phases of the Apollo P-100B control programmer and of the Apollo P-103 mission control programmer.

Purpose

These tests will be conducted to assure that the materials, parts, and design concepts employed are capable of meeting all requirements of the applicable drawings and procurement specifications. The results of this testing will increase subsystem confidence in the following areas:

1. Assurance that the subsystem will successfully complete the qualification tests

2. Proven application suitability of materials, parts, components, and circuits

3. Identifiable failure modes and rates, including the assessed probable subsystem reliability as a function of time

4. Known effects of environments, functional stresses, tolerances, and design margins

Development Testing Phases

The design and development of the control programmer and mission control programmer will follow a logical, sequential order from the design of individual circuits and components to the completed end item.

Testing will be performed at the following stages of the development of a breadboard model:

1. Individual circuits and components

2. Module and boilerplate top assemblies

3. Package

4. Subsystem

Design verification (including prequalification) tests will be run on a prototype model as a conclusion to the developmental testing. These tests will be conducted to ensure that the production subsystem will be capable of successfully passing the specified qualification tests.

Individual Circuits and Components. The class of items being tested will include such breadboard circuits as relay drivers, power supplies, current regulators, and input-output circuitry.

Dummy loads and signals will be supplied where necessary in order to test all electrical parameters as completely as possible. Specific attention will be paid to proper logic levels, component heating, regulation, and drift, where applicable. Proper circuit operation will be verified under marginal power and temperature conditions. The circuits will be monitored for radiated and conducted electromagnetic interference (EMI) susceptibility.

Modules. The items being tested at this level will consist of the breadboard circuits (or combinations thereof) that have been refined and compactly packaged in the configuration of a proposed production module.

Dummy loads and signals will be supplied where necessary in order to verify all pertinent parameters. Electrical characteristics will again be monitored while the module is subjected to the marginal conditions specified.

The modules will be subjected to mechanical stresses such as vibration, shock, and acceleration while in the normal mode of operation. Boilerplate top assemblies will be tested in order to determine their structural resistance to such factors as shock, vibration, temperature, vacuum, and over-pressure.

Package. A package is defined as one of the black boxes which compose the programmers.

Sufficient input and output test equipment will be used to ascertain that the integrated modules and components are operating as expected. The effects of vibration cross-talk caused by the wiring harness or module proximity will be investigated and corrected, if necessary.

Of prime interest during this phase of testing will be the ability of the package to operate under the environmental conditions specified in the programmer procurement specifications. The packaging will be revised as necessary to ensure that conformity to these specifications is achieved.

System. At this stage of development, all packages should be operating as the proposed production items.

Testing at this level will ensure proper signal interface, i.e., when a specific input is simulated, the correct subsystem output will be verified. When operation is initiated, the subsystem should automatically go through the specified sequence of modes of operation and issue all required commands.

Facilities and Equipment

All phases of the developmental testing will be conducted at the Autonetics Anaheim complex.

No special test equipment is required for this program. All commercial test equipment used will be calibrated by the Autonetics metrology laboratory at the required calibration interval.

5.3.2 Autonetics Qualification Test Plan

Scope

The qualification ground rules are contained in the Block I CSM Technical Specification, SID 63-313. Qualification tests will be performed on two control programmer subsystems and two mission control programmer subsystems. The qualification tests are a part of the quality assurance program defined in S&ID procurement specifications MC 901-0480B and MC 901-0529A. Environmental levels and test procedures are given in specification MC999-0050, General Test Requirements for Apollo Subcontractors and Suppliers, dated 10 June 1963.

Test Schedules

The qualification tests will be conducted in the sequence indicated in Table 5-1.

Table 5-1. Sequence of Qualification Tests

| Test | Qualification Test Unit 1 | Qualification Test Unit 2 |
|---|---|---|
| Acceptance | 1 | 1 |
| Vibration | 2 | - |
| EMI | - | 2 |
| High temperature | 3 | - |
| Low temperature | 4 | - |
| Vacuum | 7 | - |
| Oxidation | 6 | - |
| Acceleration | 8 | - |
| Humidity | 5 | - |
| Shock | 9 | - |
| Life test | - | 3 |

Qualification Test Requirements

Facilities. All environmental tests except the acceleration tests will be conducted at the Autonetics Anaheim complex. The acceleration tests will be conducted at a facility yet to be chosen.

Test Equipment. Factory test equipment will be used to perform all electrical testing of the programmers. This testing will include operation of the system during pre- and post-environmental functional tests, as well as during a specified environment. The necessary instrumentation (analog recorders, oscilloscopes, voltmeters, and so forth) will be supplied by Autonetics. All test equipment used during the qualification testing will be calibrated by the Autonetics metrology laboratory. Those items of test equipment which need to be will be certified by the Autonetics Quality Assurance department.

Items to be Tested. Tests will be performed on two control programmers and on two mission control programmers. These programmers consist of the following assemblies.

| Programmer | Assemblies |
|---|---|
| Control | Radio command controller<br>Automatic command controller<br>Sequential timers |
| Mission Control | Ground command controller<br>Spacecraft command controller<br>Attitude and deceleration sensors |

Test Conditions. Because of the limited size of the vibration and centrifuge base plates and the volume of the vacuum and oxidation chambers, the vibration, acceleration, vacuum, and oxidation tests will be run on an individual-package basis. EMI, humidity, and high-temperature tests will be conducted on a subsystem basis.

Power will be applied to the package or subsystem under test during all testing sequences except humidity and shock.

The basis for a successful test will be the completion of the specified sequence with no out-of-limits condition detected.

A complete functional test will be performed on each test package or subsystem before and after exposure to each environmental test condition. A satisfactory post-environmental functional test will satisfy the pre-environmental test requirement for the next environmental test if the subsequent test is performed within 24 hours.

Failures. A failure or malfunction will be defined as an out-of-limits functional test measurement detected by the factory test equipment, or any physical deterioration attributed to an environmental test which renders the test article (specimen) not acceptable according to Autonetics quality control standards.

If an equipment failure or malfunction occurs during a pre-environmental functional test, the malfunctioning subsystem will be repaired and the entire pre-environmental functional test will be repeated.

In the event of a failure or malfunction during an environmental test, the particular test will be terminated and S&ID will be notified. An immediate course of action will then be established by S&ID. Official contract negotiations will follow to document the particular agreements. If it becomes apparent, through repeated failures, that a subassembly or any part thereof cannot withstand the specified test environment, further testing in that environment will be suspended pending direction from S&ID Engineering. If a subsystem fails the post-environmental functional test, it will be treated as a failure during the environmental test. All failures will be reported on the Autonetics failure and replacement report form (851-D-1). Reliability Engineering will perform a failure analysis on all failures assessed as major or critical. The results of this analysis will be published on the Autonetics failure analysis report form (851-D-6).

## 5.4 S&ID DEVELOPMENT PROGRAM

S&ID automated subsystem development test responsibilities are primarily those concerning the design verification and proof of system-level hardware required to successfully integrate the automated subsystems into a specific spacecraft.

These responsibilities include not only systems management of Autonetics development activities to ensure end-item and vehicle configuration compatibility, but also the internal S&ID automated system configuration synthesis, analysis, control, verification, and checkout leading to the same end. Specifically, these tasks include the following:

1. House spacecraft test and laboratory evaluation—preliminary interface verification and determination of combined subsystems operational compatibility

2. Flight simulation and spacecraft ground control studies—analysis of the closed-loop operation and the functional and operational characteristics

3. Ground system checkout—verification of individual, combined, and integrated subsystems operation with specified design parameters

## 5.4.1 House Spacecraft Test and Laboratory Evaluation

The design and development testing of the automated subsystem will be accomplished by Autonetics. The tests will continue throughout the Apollo unmanned-mission program.

Tests performed by S&ID will cover interface verification, determination of combined and integrated subsystems operational compatibility, and evaluation of overall spacecraft performance. This testing will constitute a part of the Apollo ground qualification test program and will be composed of house spacecraft tests and laboratory evaluation of development subsystems. It is planned that these program phases will be accomplished in accordance with a schedule that will yield the maximum confidence level prior to commitment of the first hardware to flight.

All interfaces will be checked either statically or dynamically, as applicable, for the following characteristics:

1. Mechanical compatibility
2. Electrical compatibility
3. Operational compatibility, procedures, and profile
4. Failure modes and backup procedures
5. Design acceptability from an overall subsystem viewpoint
6. Operational performance characteristics and limits

Verification of the interface characteristics will be accomplished in the guidance and control laboratory in support of Spacecraft 009 and 011. This verification is the result of both Block I house spacecraft being utilized in support of manned Apollo configurations.

## 5.4.2 Flight Simulation and Spacecraft Ground Control Studies

The combined-system simulation effort is directed toward the generation of an engineering analysis and evaluation tool for evaluation of the combined closed-loop operation of guidance and control subsystems. The prime objective of the overall Apollo simulation program is the duplication of the spacecraft performance prior to flight in order to demonstrate the adequacy of the integrated subsystem design to fulfill the mission. The automated subsystem simulation studies are divided into two groups—mission evaluator studies, which include only software, and combined subsystem dynamic verification (CSDV) studies, which include software and hardware. The Spacecraft 009 evaluator study will satisfy the following objectives:

A. Ground control

1. Evaluation of ground control of the spacecraft
2. Evaluation of ground control monitoring
3. Evaluation of failure detection capability
4. Preliminary determination of criteria for ground takeover of spacecraft control
5. Evaluation of the capabilities of ground control corrective action commands

B. Attitude reference subsystem (ARS)

1. Evaluation of single-axis control of the spacecraft by using direct rotation commands and the ARS
2. Determination of the capability of using the ARS to control the spacecraft by a Euler set derived from the ARS gimbal pickoff signals and by ARS gimbal pickoff signals

C. Control programmer

1. Verification that the programmer events are necessary and adequate to fulfill the Spacecraft 009 mission requirements
2. Verification of the compatibility of control programmer events and other spacecraft events

Evaluator studies for Spacecraft 011 and subsequent will be used to achieve the objectives of categories A and C.

The Spacecraft 009 CSDV will verify the control programmer and stabilization and control subsystem interface for functional integrity and hardware compatibility. The CSDV will also be used to evaluate the closed-loop performance of the ARS. Subsystem checkout procedures for the control programmer will be the basis for evaluation of the hardware interface. A control programmer test unit will be used to control the sequential timers and to initiate the various ground commands which affect the stabilization and control subsystem.

### 5.4.3 Ground System Checkout

Building 290, Final Assembly and Checkout

Building 290, Downey, tests and operations encompass the installation of subsystems in the Apollo spacecraft modules and checkout of the spacecraft to assure that all subsystems are operating within design parameters.

Individual Subsystems Test. An individual subsystems test will be performed on the command and service modules. The purpose of this test is to verify the operation of individual subsystems. However, as the basic design concept of the automated subsystems is one of initiating responses of other spacecraft subsystems, it is not necessary to perform an individual test of the automated subsystem upon installation in the spacecraft.

Combined Subsystems Test. The performance assessment of the automated subsystem will be provided during this test phase because of its utilization as a sequencing stimulus to other spacecraft subsystems. Verification of the automated-subsystem output of sequencing signals of proper accuracy, magnitude, and quality will be provided by means of the monitoring of other spacecraft subsystem outputs by automatic checkout equipment.

Integrated Subsystems Test. The spacecraft, with the programmed flight subsystems on board, will be subjected to a series of mechanical, electrical, and pneumatic stimuli designed to exercise all of the flight subsystems. The abort modes and a simulated mission will be performed to verify spacecraft capability.

The checkout configuration and support equipment required for the programmers for Block I unmanned spacecraft are being defined; these data will be provided at a later date.